

UNSATURATED ZONE PROCESS MODEL FOR YUCCA MOUNTAIN, NEVADA

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RESEARCH OBJECTIVES

The Department of Energy is evaluating Yucca Mountain, Nevada, for the development of a potential geological repository for the permanent disposal of the nation's commercial and defense spent nuclear fuel and high-level radioactive waste. This evaluation includes analyses of the ability of the natural geologic and engineered barrier systems of this potential repository to prevent the migration of radionuclides to the accessible environment. The primary pathway has been determined to be via the groundwater aquifer below the potential repository.

APPROACH

The Unsaturated Zone (UZ) Process Model Report (PMR) describes the modeling, analysis and current understanding of fluid flow and chemical (solute and colloidal) transport through the UZ at Yucca Mountain. The primary purpose of the UZ PMR is to document models and analyses for Total System Performance Assessment (TSPA) that evaluate the post-closure performance of the UZ. The models in the UZ PMR consider two principal factors: seepage into drifts and radionuclide retardation in the UZ. Seven other factors are also considered, including: climate, net infiltration into the mountain, UZ flow above the repository, coupled processes-effects on UZ flow, advective pathways in the UZ, colloid-facilitated transport in the UZ and coupled processes-effects on UZ transport.

Most of the models in the UZ PMR are based on continuum approximations and employ the dual-permeability approach with van Genuchten equations to describe characteristic curves of both the fracture and matrix continua. The models are supported by site data collected since the early 1980s and the results of field testing in boreholes and underground drifts. Figure 1 shows some of the key models contained in the UZ PMR.

ACCOMPLISHMENTS

The major hydrogeologic units identified at Yucca Mountain are, from land surface to water table: Tiva Canyon welded unit (TCw), Paintbrush nonwelded unit (PTn), Topopah Spring welded unit (TSw), Calico Hills nonwelded unit (CHn), and Crater Flat undifferentiated unit (CFu). They are partially saturated with water.

The potential repository will reside at a depth ranging from 200 to 425 m below ground surface, and from 175 to 365 m above the water table, in three geological units within the TSw. More than 80% of water flow at the repository horizon is through fractures, while the remainder flows through the low permeability (10^{-16} to 10^{-18} m²) rock matrix. Below the horizon, perched water bodies have been found primarily in the northern part of the repository area, where low-permeability zeolitic rock units are abundant. The presence of the perched water bodies creates the potential for the lateral flow of water to nearby high-permeability vertical features, such as faults.

The rate of water seepage into drifts is expected to be considerably less than the prevailing percolation flux and may be zero for areas where the percolation flux is lower than the seepage threshold for that location. This is because the drifts act as capillary barriers which divert most of the flowing water around the drifts.

As the radioactive waste emits heat, coupled thermal-hydrological-chemical processes in the UZ rock mass may be important for periods of up to about 10,000 years. The energy emitted will heat up the entire UZ, extending 600 m

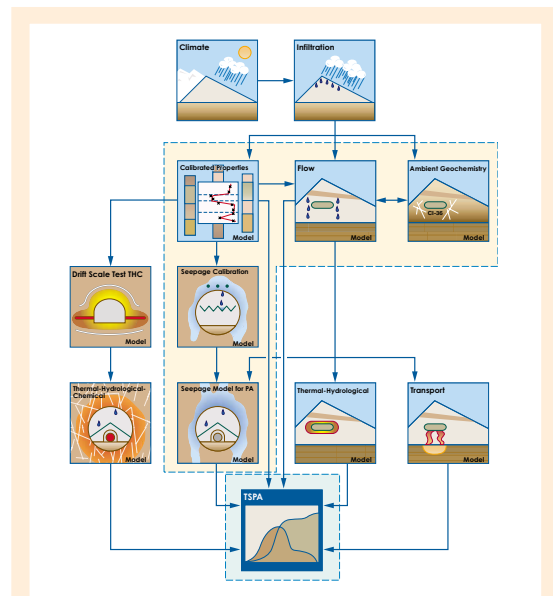


Figure 1. Process models included in the Unsaturated Zone Process Model Report.

from the potential repository footprint, with estimated temperature increases of 30 to 35°C at the water table, and up to 5°C at the ground surface.

SIGNIFICANCE OF FINDINGS

The UZ PMR process models are abstracted for use in TSPA. The degree of abstraction of these models varies from direct use of the process model in TSPA to using the model to justify neglecting certain processes. In the development of the process models, the uncertainties in parameters, processes, and conceptual models are identified and qualified where possible; TSPA then evaluates the importance of these uncertainties on the performance of the potential repository.

ACKNOWLEDGEMENTS

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